REPORT DOCUMENTATION PAGE

Form Approved
OMB NO. 0704-0188

1. AGENCY USE ONLY (Leave Blank)	2. REPORT DATE 06/26/00	3. REPORT TYPE AND DATES COVERED Final Progress Report 08/01/99-03/31/00

4. TITLE AND SUBTITLE
Efficient Electromagnetic Scattering Models for UWB SAR Calibration

5. FUNDING NUMBERS
DAAD19-99-1-0330

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8. PERFORMING ORGANIZATION REPORT NUMBER

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U. S. Army Research Office
P.O. Box 12211
Research Triangle Park, NC 27709-2211

10. SPONSORING / MONITORING AGENCY REPORT NUMBER
40134.1-EL-MUR

11. SUPPLEMENTARY NOTES
The views, opinions and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy or decision, unless so designated by other documentation.

12 a. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for public release; distribution unlimited.

12 b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

In this project we develop a multi-level fast multipole algorithm for the analysis of electromagnetic scattering from general conductong (3D) targets above or within a lossy half space. The model is applied here to simulated scattering from fiducial targets, of interest for UWB SAR calibration.

14. SUBJECT TERMS
scattering, calibration

15. NUMBER OF PAGES
3

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION ON THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	**UNCLASSIFIED**	**UNCLASSIFIED**	**UL**

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A. Statement of the Problem Studied

Over the three years of funding, significant progress has been made on both signal processing and electromagnetic modeling for FOPEN and GPEN SAR. Considering the modeling, we have developed a fast multipole method (FMM) simulator for electrically large targets embedded in a half-space region (i.e., for targets in the vicinity of soil). The model is applicable to very general targets, including buried or surface unexploded ordnance (UXO), vehicles and weapons. The model is also applicable for simulating the scattered fields from fiducial targets (trihedrals) placed above soil, these models playing a critical role in the calibration of foliage penetrating (FOPEN) radar systems, such as the ARL BoomSAR. In the future we will apply the FMM model for calibration of the BoomSAR, with this playing a critical role in the development of automatic target recognition algorithms for FOPEN systems.

B. Summary of Most Important Results

During the course of this research, two significant developments have occurred. For the first time, the fast multipole method (FMM) has been extended to the case of targets in the presence of a half space. This is a notable escalation in complexity vis-à-vis previous work in this field, which has heretofore been restricted to the case of free-space scattering. Significant work has been undertaken to properly handle the dyadic half-space Green's function.

The other significant development involves the hidden Markov model (HMM) as applied to the SAR problem. Hidden Markov models are widely applied in speech processing, where they have been very effective. We are the first to expend HMMs to SAR processing, in the context of a physics-based matching-pursuits feature parser. The HMM is an entirely new processing paradigm for this problem class, opening up a new direction of basic research.

C. Refereed Publications

[1] N. Geng, D. Jackson, and L. Carin, "On the resonances of dielectric bodies of revolution buried in a lossy, dispersive layered medium," IEEE Trans. Antennas Propagat., vo. 47, pp. 1305-1313, Aug. 1999.

[2] N. Geng, M. Ressler, and L. Carin, "Wideband VHF scattering from a trihedral reflector situated above a lossy dispersive halfspace," IEEE Trans. Geoscience and Remote Sensing, vol. 37, pp. 2609-2617, Sept. 1999.

[3] J. He, T. Yu, N. Geng and L. Carin, "Method-of-moments analysis of electromagnetic scattering from a general three-dimensional dielectric target embedded in a multi-layered medium," Radio Science, vol. 35, pp. 305-313, Mar.-Apr. 2000.

[4] N. Geng, A. Sullivan and L. Carin, "Multi-level fast-multipole algorithm for scattering from conducting targets above or embedded in a lossy half space," IEEE Trans. Geoscience Remote Sensing, vol. 38, pp. 1567-1579, July 2000.

[5] P. Runkle, L. Nguyen, J. McClellan and L. Carin, "Multi-aspect target detection for SAR imagery using hidden Markov models," accepted for publication in the IEEE Trans. Geoscience and Remote Sensing.

[6] T. Dogaru and L. Carin, "Multiresolution time-domain analysis of scattering from a rough dielectric surface," accepted for publication in Radio Science

[7] N. Geng, A. Sullivan and L. Carin, "Fast multipole method analysis of scattering from a three-dimensional target in a half-space environment," submitted to the IEEE Trans. Antennas Propagat.

[8] T. Dogaru and L. Carin, "Application of multiresolution time-domain schemes to two-dimensional electromagnetic scattering problems," submitted to the IEEE Trans. Antennas Propagat.

[9] A. Sullivan, R. Damarla, N. Geng, Y. Dong and L. Carin, "Ultra-Wideband Synthetic Aperture Radar for Detection of Unexploded Ordnance: Modeling and Measurements," submitted to IEEE Trans. Antennas Propagation

[10] P. Bharadwaj, P. Runkle, L. Carin, J.A. Berrie and J.A. Hughes, "Multi-aspect classification of airborne targets via physics-based hidden Markov models and matching pursuits," submitted to IEEE Trans. Aerospace and Electronic Systems

[11] J. He, N. Geng, L. Nguyen and L. Carin, "Rigorous modeling of ultra-wideband VHF scattering from tree trunks over flat and sloped terrain," submitted to IEEE Trans. Geoscience and Remote Sensing

[12] T. Dogaru and L. Carin, "Multiresolution Time-Domain Using Biorthogonal Wavelets," submitted to IEEE Transactions on Microwave Theory and Techniques

[13] Y. Dong, P. Runkle, L. Carin, R. Damarla, A. Sullivan, M. Ressler and J. Sichina, "Multi-Aspect Detection of Surface and Shallow-Buried Unexploded Ordnance via Ultra-Wideband Synthetic Aperture Radar," submitted to IEEE Trans. on Geoscience and Remote Sensing

D. Participating personnel

Dr. Norbert Geng (post doc)
Dr. Anders Sullivan (post doc)

E. Report of Inventions

None